IMPROVED CONCRETE POLE CAST MOLDING SYSTEM AND METHOD

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BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention relates generally to structural support members, and in particular, to molded concrete structures and methods for producing the same. More particularly, the present invention relates to a method and system for casting a concrete pole that leverage contour characteristics of a casting mold to facilitate an efficient production cycle.

2. Description of the Related Art:

Vertical support structures, such as utility poles for telephone and power lines, are made from various materials having requisite strength and durability to safely function in a variety of environments. Wood and metal are among the most common material compositions used for utility pole construction, each having drawbacks and disadvantages. For example, poles made of metal are often subject to rust and corrosion, and are electrically conductive and therefore incompatible with applications requiring electrical insulating properties. In addition, the materials and manufacturing expenses of metallic poles makes them a less practical option for the vast quantities required for geographically widespread utility pole applications.

Traditionally, utility poles been manufactured predominantly of wood, which is relatively abundant, inexpensive, nonconductive. However, wood poles exhibit internal structural asymmetries and inconsistent material properties in the form of knots, checks, shakes and splits that tend to negatively impact strength and load bearing properties of the poles. Furthermore, wood poles are susceptible to damage from rot and decay as well as from attack by a host of insects, birds and microbiological agents, resulting in a

reduced design life and necessitating a design setoff to compensate for the temporal shift in strength over the pole's service life. Maintenance is required in combating the foregoing environmental hazards to which wood poles are susceptible such as by coating and injecting the wooden structural members with a preservative, such as creosote. Furthermore, the toxic properties of such substances result in greater regulation and associated costs.

In view of the many problems and inefficiencies relating to wood and metal, concrete poles have come into widespread use for many utility pole applications such as for power transmission and distribution, roadway and other highmast lighting, traffic signals, communications antennas, etc. Concrete poles are highly durable and are substantially maintenance free. Unlike other pole construction materials, concrete suffers no loss of strength over the years, being resistant to termites, woodpeckers, fire, rot and corrosion. Its durability in soil permits the economy of direct burial without the use of contaminating chemical treatments. The precision engineering of concrete pole casting ensures the poles have minimum strengths and other load-bearing characteristics thus minimizing the uncertainty of vertical support design plans and enabling the poles to remain unguyed thereby saving space and eliminating clutter. In addition, concrete poles provide a more progressive aesthetic appearance in metro areas and, constituting an inert material, can be recycled or accepted as clean fill at the end of their service life.

Concrete poles are manufactured in a wide range of shapes, strengths and sizes, to address many different applications and are tapered for balance and reinforced, typically with metallic reinforcing bar, or rebar, to provide adequate strength and deflection characteristics. Two fundamental approaches are used for casting concrete poles. Traditionally, concrete poles have been cast using the traditional, so-called wet cast technique in which the concrete is poured into a basin-like mold where it cures and sets as reinforced by rebar which is pre-positioned in the mold. The most common mold forms used for the wet cast type poles typically have either a square cross-section or a T-shape based cross-section used for forming H-beam contoured poles. In either case, the geometry of the mold cast requires that the poured concrete remain in the mold until the concrete has set. The other basic approach, which has come into widespread use, is to

form the concrete pole as a hollow cylindrical structure by using a substantially cylindrical cage of rebar and depositing concrete by centrifugal casting inside and outside the rebar cage.

While concrete enjoys the aforementioned advantages and benefits over other pole construction materials, the foregoing molding processes for concrete poles are time consuming and costly. Specifically, and as mentioned above, the conventional processes by which concrete poles are cast require that a cast pole remain enclosed within its mold until the pole has substantially set at which time the mold can be removed from the hardened pole. The time for adequate curing of the concrete is typically from one to several days, resulting in the casting process being limited by the number of available molds. As each mold is a very large and expensive piece of equipment, this need for multiple casts imposes substantial additional cost and delay to the production cycle.

It can therefore be appreciated that a need exists for an improved concrete pole and method and system for producing the same that reduces or eliminates the foregoing production cycle costs and delays. The present invention addresses such a need.

SUMMARY OF THE INVENTION

A method and apparatus for casting an elongated pole member are disclosed herein. In accordance with one embodiment, the method includes providing an elongated casting mold having a lengthwise rim boundary defining a planar open mouth from which a cast pole member, while still in a substantially plasticized state, can be slidably removed without damaging the mold or comprising the cast member. The elongated casting mold is positioned in a horizontal molding orientation where concrete casting material is poured into the casting mold and the mold is vibration treated to remove air pockets. After withdrawing rebar constraint pins, a final vibration cycle fills the air pockets left thereby. The mold is then rotated approximately 180° about its lengthwise axis to a horizontal demolding orientation in which the lengthwise open rim boundary of the mold is facing downward and the cast member can be slidably removed therefrom with the flat backside of the U-shaped cast member supported upwardly by the receiving surface. The receiving surface supporting the flat backside cast member surface is then lowered while the mold is held substantially stationary such that the cast member is gravity released from the mold.

All objects, features, and advantages of the present invention will become apparent in the following detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself however, as well as a preferred mode of use, further objects and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1A depicts a concrete pole casting apparatus in accordance with a preferred embodiment of the present invention;

Figure 1B illustrates an overhead view of the concrete pole casting apparatus shown in **Figure 1A**;

Figure 2A depicts a perspective view of a U-channel casting mold in accordance with the present invention;

Figure 2B illustrates a cross-section view of a U-channel casting mold in accordance with the present invention;

Figure 3 depicts a cross-section view of a transition shoulder section of a casting mold in accordance with the present invention;

Figure 4A illustrates a front view of a cast member in accordance with the present invention;

Figure 4B depicts a cross-section view of the cast member shown in **Figure 4A**; and

Figure 5 is a flow diagram illustrating process steps performed during casting of an elongated concrete pole in accordance with the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention is described in a preferred embodiment in the following description with reference to the figures. While this invention is described in terms of the best mode for achieving this invention's objectives, it will be appreciated by those skilled in the art that variations may be accomplished in view of these teachings without deviating from the spirit or scope of the present invention.

The present invention is directed to an improved method and apparatus for casting elongated concrete pole members such as are used to support power lines, street lights, etc. A specialized casting mold is designed to enable the typically very large (typically 3 to over 50 meters) cast members to be gravity released onto a receiving platform while in a substantially plasticized state prior to curing, thereby freeing the casting mold to be used for subsequent molding cycles while the released cast members cure and harden. To this end, the casting mold of the present invention has an inner mold liner contour shaped to produce an elongated U-channel shaped cast member having a substantially flat backside forming a base from which two lateral side walls and one or more crosswise supporting transition shoulders extend outwardly. To facilitate release of the cast member before curing, all surface edges extending outwardly from the flat backside preferably taper from wider to narrower. Floating reinforcing bar (rebar) is deployed lengthwise within the mold as loosely restrained by horizontal and vertical rebar retention pins before the concrete is poured to provide the requisite strength and load-bearing characteristics. As explained in further detail with reference to the figures, the present invention employs molding/demolding processing steps that leverage the structural characteristics of the casting mold to facilitate a rapid and substantially continuous casting cycle and production process for concrete poles.

With reference now to the figures, wherein like reference numerals refer to like and corresponding parts throughout, and in particular with reference to **Figures 1A** and **1B**, there are depicted alternate views of a concrete pole casting apparatus in accordance with a preferred embodiment of the present invention. Specifically, a concrete pole casting apparatus **5** generally comprises a mold support member in the form of one or

more pivoting armatures **2** that are hinged and supported on vertical supports **12** and corresponding base members **4**. Pivoting armatures **2** are preferably lever-like members rotatably driven by a motor or other driving mechanism (not depicted) and utilized to support and rotatably adjust the orientation of a casting mold **11** during a given molding/demolding cycle in the manner specified herein.

Concrete pole casting apparatus **5** further includes a receiving platform **6** that is vertically adjustable, such as driven by a motor **8** or other mechanical or electromechanical driving means, along drive tracks **19** on vertical supports **12**. As explained in further detail below in reference to the cast molding method of the present invention, the vertical position of receiving platform **6** is advantageously adjusted during a molding/demolding cycle to facilitate a more efficient demolding process with a reduced risk of damaging the cast member when the cast member is released in a substantially plasticized state.

Casting mold **11** is an elongated, typically metallic member that is itself a molded or extruded piece having a molding contour for forming a cast member having the desired characteristics. As shown in **Figures 1A** and **1B**, casting mold **11** is fixedly attached in a horizontal disposition on one side across one or more of pivoting armatures **2**. Welding or a variety of removable mechanical fasteners such as clamps, bolts, etc., may be utilized to fixedly attach casting mold **11** to armatures **2** in the manner shown. The casting shape rendered by casting mold **11** is determined by the inner contour of the substantially rigid, lengthwise open vessel liner bounded at its upper edge by an open rim boundary **25** defining a lengthwise planar boundary forming the flat back of the pole members cast within mold **11** such as the U-channel contoured casting member **18** shown in the depicted embodiment and in **Figures 4A** and **4B**. The material constituting casting mold **11** is preferably a metallic alloy such as stainless steel or a sufficiently strong ceramic material.

In its role as a mold for relatively long vertical support members requiring a low center of gravity when vertically erected, and as shown in the depicted embodiment, the lengthwise contour of casting mold **11** is generally trapezoidal with the lateral edges of

the mold liner narrowing in a smoothly tapering manner from one end to the other along lengthwise axis **23**. The overhead view shown in **Figure 1B** reveals the inner liner contouring of casting mold **11** through the open mouth defined by the lengthwise open rim boundary **25** which defines the upper mold boundary for concrete casting material **15** when the cast is poured in the horizontally supported molding orientation, and from which a cast member **18** is subsequently slidably removed after rotating casting mold **11** to the horizontal demolding position **34** as shown in **Figure 1A**. As utilized herein, "casting material" refers to an uncured water admixed material such as a concrete, sand and water slurry mixture that is utilized for casting concrete pole members. In a preferred embodiment, casting material **15** is preferably low water content concrete slurry mixture having relatively low fluidity characteristics.

Referring now to **Figures 2A** and **2B**, there are depicted perspective and cross-section views, respectively, of a casting mold apparatus in accordance with the present invention. As illustrated therein, casting mold **11** includes multiple aligned fastener holes **17** through which removable horizontal rebar retention pins **22** are inserted to provide a floating constraint for longitudinally disposed rebar members **24**. The contour of casting mold **11** forms a pair of lobes **31** defined by the outer lateral sides of the mold and a longitudinal recess area **28**. A substantially flat, elongated capping member **39** is affixed over the open mouth surface area defined by open rim boundary **25** during vibration treatment of the concrete casting material **15** as explained in further detail with reference to **Figure 5**. Protruding downwardly from capping member **39** into the lobe areas **31** of the mold cavity are pairs of removable vertical retention pins **26** for securing rebar **24** in cooperation with horizontal removable pins **22** in the manner depicted in **Figure 2B**.

The predominant lengthwise U-channel cross-section contour of casting mold **11** illustrated in **Figures 2A** and **2B** is interrupted at selected support joint positions by multiple transition shoulder areas **27** as shown in **Figures 1B** and **3**. Referring to **Figure 3**, there is depicted a cross-section view of a transition shoulder section of the cast mold apparatus. Unlike the U-channel cross-section areas defined by lobes **31** divided by lengthwise recess **28** as depicted in **Figures 2A** and **2B**, the contour of the transition shoulder is rectangular, or preferably, slightly trapezoidal having no recessed area.

Furthermore, the rebar **24** is securely retained within the transition shoulder during the molding process described hereinbelow by a spacer bar **33** in cooperation with a lodging pin **32**.

Referring to **Figures 4A** and **4B** in conjunction with **Figure 1A**, there are illustrated front and cross-section views of cast member **18** as it is formed within casting mold **11** and slidably released therefrom in accordance with the present invention. As shown in **Figure 1A**, cast member **18** is released with casting mold **11** in a horizontal demolding orientation that is approximately 180° rotated about the lengthwise axis from the horizontal molding orientation in which the concrete is poured into the mold with open rim boundary **25** facing upward. In the demolding orientation, while casting mold **11** is in the rotated demolding position **34**, the lengthwise open rim boundary **25** is facing downward and the open mouth defined thereby is covered by an upper surface **9** of support rack **14**, which is secured to casting mold **11** by mechanical fastening means such as hydraulic clamps following pouring and settling casting material **15** within the mold. Depending on the desired demolding sequence embodiment, receiving platform **6** is either raised or is pre-positioned by motor **8** to a level on vertical supports **12** such that when pivoting armature **2** is rotated to demolding position **34**, the bottom surface of support rack **14** rests on and is supported by the top surface of receiving platform **6**.

Once the weight of the mold/cast member combination is substantially supported by receiving platform **6**, the hydraulic clamps or other mechanical fasteners (not depicted) used to attach support rack **14** to cast mold **11** are removed or otherwise released. In a preferred embodiment of the present invention, receiving platform **6** is then lowered such as by reversing motor **8** in a slow, controlled manner to allow cast member **18** to be gravity released in a slidable manner from the interior lining of casting mold **11** as supported by the upper surface of receiving platform **6**.

As further depicted in **Figure 1A**, the cast member **18** is released in the horizontal demolding orientation in which the substantially flat back surface **10** of cast member **18** is vertically supported by receiving platform **6** via support rack **14** in the depicted embodiment. **Figure 4A** depicts an overhead view of cast member **18** without the support rack and illustrates various features such as multiple transition shoulder regions

38 supporting the lateral side lobes disposed across recessed areas **36** that define the characteristic U-channel cross-section contour of the cast member of the present invention. In order to facilitate the slidable gravity release from casting mold **11**, the molded contour of cast member **18** is preferably tapered to narrow as is extends from the substantially flat backside **10** toward the lengthwise "front" side of cast member **18** depicted in **Figure 4A** (as from right-to-left in the lengthwise cross-section shown in **Figure 4B**).

This tapered contour having its widest edge at the back surface **10** is particularly advantageous when utilized with the molding/demolding method set forth herein. The shape imparted on cast member **18** by mold **11** enables cast member **18** to be released while the casting material is still in its uncured plastic phase. Specifically, the inwardly (from backside **10**) tapering cross section contour of each of side walls **41** and transition shoulders **38** of cast member **18** result in a cast member center of gravity that is maximally shifted toward back side **10** thereby facilitating a gravity release in the depicted demolding orientation. This tapered contour further serves to provide maximum stability and support for the upwardly extending side walls **41** and transition shoulders **38** when cast member **18** has been released in the horizontal demolding orientation. For the foregoing reasons, and others that can be understood by those skilled in the art upon viewing the presently disclosed embodiments, the contouring of casting mold **11** facilitates and operates synergistically with the demolding process explained with reference to **Figure 5** to facilitate gravity release and subsequently provide sufficient resistance to downward creep of the uncured cast member as would otherwise occur using conventional concrete pole forms when an unsupported edge is gravity drawn downward and deformed while the mold is in the plastic phase.

With reference to **Figure 5**, there is depicted a flow diagram illustrating process steps performed during casting of an elongated concrete pole in accordance with the present invention. The casting cycle process begins as shown at step **62** and proceeds to step **64** with rebar **24** disposed and anchored in lengthwise alignment with the mold cavity lobes **31** as constrained by rebar retention pins **22** and **26** in the floating manner depicted in **Figures 2A** and **2B**. After positioning the rebar, and following a conventional concrete slurry mixing procedure, the concrete slurry is poured into the

mold cavity as illustrated at step **66**. As utilized herein, "concrete" refers to casting material suitable for constructing elongated pole structures such as low water content concrete mixtures. Next, and as depicted at step **68**, the poured casting material is vibrated, using well-known air vibrators or the like, to remove trapped gases from the poured casting material.

After the gas pockets formed around crevices within the mold cavity such as around rebar members **24** have been substantially diminished or removed, vertical and horizontal rebar retention pins **26** and **22** are withdrawn from their respective embedded positions within casting mold **11** as depicted at step **69**. After a final, typically brief vibration step for removing the pin removal gaps (step **72**), and as illustrated at step **74** the support rack **14** is removably affixed over the open rim boundary of casting mold **11**. Hydraulic clamps or other such removable mechanical-type fasteners may be utilized for capping the open rim boundary of casting mold **11** with support rack **14**. It should be noted that steps **64** through **74** constitute a "molding phase" of a casting cycle during which armature **2** of concrete pole casting apparatus **5** is maintained in the position shown in **Figures 1A** and **1B** with the open rim boundary **25** of mold **11** facing upward.

Proceeding as depicted at step **76**, a "demolding phase" is commenced with casting mold **11** being rotated approximately 180° about lengthwise axis **23**. In the depicted embodiment, this rotation is achieved by pivoting armatures **2** from the molding position to a demolding position **34** as shown in **Figure 1A**. It should be noted that although the rotation of the casting mold as depicted in the present embodiments is accomplished by an arc-like rotation of an armature on which the mold is affixed and which includes both linear displacement as well as rotation of the mold, the present invention is not intended to be so limited. For example, the rotation of casting mold **11** about its lengthwise axis **23** may alternatively be accomplished using other electromechanical means that directly rotate mold **11** about axis **23** prior to or without the need for such linear displacement. In the demolding position, casting mold **11** is oriented such that the rim boundary **25** is facing downward and the concrete casting material is supported by support rack **14**. The mold rotation step is preferably performed

immediately following the aforementioned vibration and capping procedure prior to the casting material **15** curing.

Step **76** further includes the process steps and subsets required to position the mold and support rack combination such that the flat backside of the cast member **18** is supported by receiving platform **6**. In one embodiment, the relative positioning between the mold and receiving platform **6** is achieved by raising platform **6** until the upper platform surface contacts the bottom surface of support rack **14** following rotation of armatures **2** to demolding position **34**. In an alternate embodiment, receiving platform **6** is pre-positioned such that upon rotation of armatures **2** to demolding position **34**, the bottom of support rack **14** is resting in abutment with the upper surface of the receiving platform.

Following the rotation of mold **11** via pivoting armatures **2**, and in a beneficial feature of the casting process illustrated at step **78**, receiving platform **6** is lowered by controlled actuation of motor **8** such that the casting material **15** is gravity-drawn from mold **11** as a cast member **18** onto the upper surface of the receiving platform while armatures **2** are maintained substantially stationary. Following the demolding phase comprising steps **76** and **78**, the casting cycle terminates as shown at step **80** at which point mold support armatures **2** are free to re-position mold **11** back to the molding position in preparation for the next cycle. In a preferred embodiment, a dry mix type of concrete is utilized due to its relatively low uncured flow characteristics.

While this invention has been described in terms of several embodiments, it is contemplated that alterations, permutations, and equivalents thereof will become apparent to one of ordinary skill in the art upon reading this specification in view of the drawings supplied herewith. It is therefore intended that the invention and any claims related thereto include all such alterations, permutations, and equivalents that are encompassed by the spirit and scope of this invention.